PROCEEDINGS

of the

Caulerpa taxifolia Scientific Review Panel

February 2, 2002

San Diego, California, U.S.A.

Host:

Sponsors:

California Department of Fish and Game, Habitat Conservation Planning Branch
U.S. Fish and Wildlife Service – Aquatic Nuisance Species Task Force

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ACKNOWLEDGMENTS

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Thanks to the organizers California Department of Fish and Game employees Susan Ellis (Invasive Species Coordinator) and Bill Paznokas (Staff Scientist and Vice-Chair of the Southern California *Caulerpa* Action Team) effectively organized the Panel's work. Sarah Calzada (Biologist, Habitat Conservation Planning Branch) compiled the meeting notes used in this report. Their efforts made the Workshop a logistical success.

Thanks to the participants Thanks to the dedicated members of the Scientific Review Panel. Their willingness to engage, their ability to focus on task, their skill in articulating and working with complex topics, and their agreement to take on joint problem solving were critical success elements. Thanks for that spirit of collaboration. Special thanks to Merkel and Associates, Susan Williams (Director, Bodega Bay Marine Lab, U.C. Davis), and Southern California *Caulerpa* Action Team members Bruce Posthumus, Bill Paznokas, and Bob Hoffman for providing technical material in support of the scientific review.

THE CHALLENGE

If a new *Caulerpa taxifolia* infestation occurs, is the eradication response being used in California suitable and does it have an appropriate probability of succeeding in the eradication of a new infestation?

This question formed the core of a scientific assessment of efforts to eradicate *Caulerpa taxifolia*, a deleterious marine invasive plant in California. Commissioned by the California Department of Fish and Game, an international panel of scientists convened on February 2, 2002 to provide managers with a peer review of their eradication efforts using this question as a guide. This report presents the findings from the Scientific Review Panel.

Caulerpa taxifolia[1] was discovered in two southern California marine lagoons in 2000 (Agua Hedionda Lagoon on 12 June and Huntington Harbour on 27 July). These infestations were recognized as significant, immediate threats to marine habitats in California and to the commercial and recreational activities dependent on these marine waters. A rapid eradication response was mobilized by affected government agencies and private entities and resulted in development of an administrative management structure in the form of the Southern California *Caulerpa* Action Team. The Team quickly initiated an eradication program. The State of California made possession of *C. taxifolia* illegal along with a selection of look-alike species and other presumed *Caulerpa* invaders. A purpose for this law is to prevent further, human-caused spread of *C. taxifolia* (California Fish and Game Code Section 2300).

The need for a rapid response was evident from experiences with *C. taxifolia* infestations in other parts of the world, notably the Mediterranean Sea and Australia. Control efforts on these infestations have been largely unsuccessful. As a result, there has been substantial ecological degradation and economic loss. In the United States, the federal government has banned *C. taxifolia* as a noxious weed. Internationally, it is ranked as one of the top 100 invasive species in the world, according to the International Union for the Conservation of Nature (i.e., The World Conservation Union). The California response embodies lessons learned from other areas, most notably the importance of a rapid response and a focus on eradication, not management or containment, as the necessary program objective if ecological and economic harm is to be avoided.

[1] For more background on the species see the California Water Quality Control Board web site at: http://www.swrcb.ca.gov/rwqcb9/News/Caulerpa_taxifolia/caulerpa_taxifolia.html.

Another lesson learned from other areas is the importance of routinely assessing the eradication efforts and using these results to make program changes (i.e., adaptive integrated pest management). The notion is to create information feedback loops that promote explicit learning from ongoing eradication efforts. California law, via the Marine Life Management Act (i.e., the Keeley Bill), promotes such learning by mandating the use of scientific information to manage California's marine resources and by identifying peer review as the recommended tool. The Scientific Review Panel reported on here is the first peer review of California's *Caulerpa taxifolia* eradication program as envisioned by the Keeley Bill.

THE SCIENTIFIC REVIEW PANEL PROCESS

The Scientific Review Panel (Table 1) was comprised of leaders from the scientific community recognized for their work on *Caulerpa taxifolia*, marine plant biology, marine plant infestation management, and/or marine engineering. The members were selected by Diana Jacobs, Science Advisor for the California Department of Fish and Game and by Robert Hoffman, National Marine Fisheries Service with input from the Southern California *Caulerpa* Action Team.

The goal of the scientific review was to provide advice to California managers about the efficacy of the current eradication efforts. The objectives for the Panel's work were to:

$ Analyze the information on invasion and control provided by the contractor [responsible for monitoring, eradication, and reporting];
$ Examine characteristics of infestation site(s);
$ Determine viability and extent of growth;

Table 1. The *Caulerpa taxifolia* Scientific Review Panel.

Mr. David Cannon
Everest International Consultants, Inc.
Long Beach, CA USA

Dr. James Carlton
Williams College
Mystic, CT USA

Dr. Giulia Ceccherelli
University Sassari
Sassari, Italy

Dr. Paul Dayton (unable to attend)
Scripps Institute of Oceanography
La Jolla, CA USA

Dr. Chad Hewitt
CSIRO Marine Research, CRIMP
Perth, Australia

Dr. Alexandre Meinesz
University of Nice
Nice, France

Dr. Jeanine Olsen
University of Groningen
Haren, Netherlands

Dr. Thierry Thibaut
University of Nice
Nice, France

Dr. Cynthia Trowbridge
Oregon State University
Newport, OR USA

Dr. Ante Zuljevic
Inst. Oceanography and Fisheries
Split, Croatia

Additional experts participating:

Dr. Alan Millar
Royal Botanical Gardens
Sydne, Australia

Dr. Wytze Stam
University of Groningen
Haren, Netherlands

$ Assess control effectiveness;
$ Establish a monitoring protocol; and
$ Make recommendations to State and Federal regulators for future measures.

The Panelists participated in two events in response to these objectives. First was the International *Caulerpa taxifolia* Conference held on January 31 - February 1, 2002 in San Diego, California. The conference had the goal of fostering scientific collaboration and information exchange. By bringing together scientists, resource managers, industry representatives and other stakeholders, the conference provided substantial detail on the California infestations as well as information on the biology and management of the plant around the world. National, regional, and local experts attended the conference and participated in the program.

The second event for the Scientific Review Panel was participation in a facilitated meeting on February 2, 2002 to assess the California eradication program and formulate observations and recommendations for improvement. The agenda for this meeting (Appendix 1) was designed to draw out collective scientific opinions where they existed and to provide explanations and interpretations of the panelists' opinions and observations about California's eradication effort.

MANAGEMENT HISTORY: ASSESSMENT AND DISCUSSION

Critique, not criticism. The Panel felt it important to establish that their work is a program review to improve California's eradication program for *Caulerpa taxifolia,* not a fault-finding process. While aggressive program changes are warranted (see recommendations), the Panel acknowledged that eradication efforts are occurring under uncertainty. The Panel viewed its work as fostering active not passive management in an adaptive, integrated pest management framework (i.e., one where management actively and constantly learns from its own program experiences). This was the tone of the discussions and is the intent for the Panel's conclusions and recommendations presented here.

Exercise - Management History Assessment

The entry point for the Scientific Review Panel's deliberations was to consider the efficacy of California's current *Caulerpa taxifolia* eradication efforts using the seed question:

If a new *Caulerpa taxifolia* infestation occurs, is the eradication response being used in California suitable and does it have an appropriate probability of succeeding in the eradication of a new infestation?

The Panelists were first asked to consider all they had learned about California's eradication efforts and provide their considered scientific opinions about the probable success of this eradication approach if there is a new infestation. To do this each scientist scored their opinion on a continuous scale from minimum chance of success (0% prospect of success) to maximum chance of success (100% prospect of success) (Figure 1).

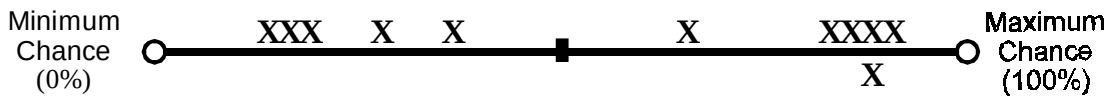

Figure 1. Scientific Review Panelists' opinions about the likelihood of current *Caulerpa taxifolia* eradication efforts in California totally eradicating a new, similar infestation. Each scientist's opinion denoted with an X.

Discussion - Management History Assessment

Results: Four main results emerged from the management assessment exercise and the discussion it generated.

1. There is a consensus of the Scientific Review Panel that eradication is a potentially achievable outcome for the current, known *C. taxifolia* infestations in California,

2. There is not a consensus scientific opinion about the likelihood of total eradication of *C. taxifolia* in California using the current eradication approach,

3. None of the scientists rated the current eradication effort as having a maximum chance of totally eradicating existing *C. taxifolia* infestations, and

4. Scientific input has been deficient up to this point.

Conclusions: From these results, the Scientific Review Panel concluded that:

1. Eradication, not control or management, is the appropriate objective in California,

2. If the same eradication approach continues eradication is not probable (i.e., maintaining the status quo is not the best policy),

3. Substantial program changes are warranted if total eradication is to be achieved (see recommendations), and

4. The objective of science-based management has not been met.

Exercise: Sustaining and Restraining Factors Assessment

To elucidate the underlying logic and assumptions in the scientists' assessments depicted in Figure 1, the Panelists were asked to list the factors that caused them to rate the existing eradication efforts as they did. First they were asked to list those factors that are sustaining or supporting the current level of partial eradication (Table 2). Second, they were asked to list those factors that are restraining, or holding back eradication success (Table 3). Using small slips of paper, each Panelist listed these factors, one idea per piece of paper, and then posted them on the same minimum-to-maximum scale of Figure 1. Doing this gave each person's assessment of the importance of each sustaining or restraining factor in the eradication efforts. Because there were many ideas (i.e., slips of paper) generated by the scientists, it is impractical to reproduce these on a chart equivalent to Figure 1. Therefore, the sustaining and restraining factors are presented in separate tables. The factors were each ranked by the person presenting it. Those rated as most important appear nearer the top in Tables 2 and 3. This part of the meeting was intended to capture each individual's thinking in an organized way so the Panel could use it in formulating recommendations later in the meeting. Thus, Tables 2 and 3 are catalogues of all the ideas presented for discussion, not a consensus of the Panel.

Table 2. Sustaining Factors

Listing of the factors the Scientific Review Panelists considered as sustaining or supporting the likelihood of eradication success. Each factor was ranked by the person offering it and presented here with those factors rated as most important appearing nearer the top of the table. This is a catalogue of all the ideas presented for discussion, not a consensus of the Panel. When more than one person made the same comment, (*x* people) signifies the number of people listing the same factor at the same importance level. If two or more scientists made the same comment but rated it at different importance levels, the comment appears more than once in the table. The scientist's words were used here with any facilitator's explanatory notes inside [brackets].

- Asked for help from foreign scientists
- Rapid response (3 people)
- Formation of SCCAT[2]
- Level of funding dedicated to the problem
- High frequency of surveys
- Managed to eradicate a large portion of the population within one year
- Rapid response (survey and eradication of the two infested areas)
- Technique of eradication with no remnant toxics
- Good initial response (quick and decisive)
- Eradication is going well
- Situation is under control
- Team building
- Persistence
- Agreement on outcome/goal (eradication [not management or control])
- Effective funding procurement
- Experience from the Mediterranean Sea (in Croatia) indicates California eradication is possible
- Rapid response
- Continuous surveillance
- Initial action plans
- Tarp and chlorine - effective eradication method - no re-growth
- Organized into mission-oriented team
- American psyche ["Can-Do" attitude]
- Dedicated effort (not just a contract)
- Rapid response
- Energetic, dedicated concern - they are passionate about eradication
- Rapidity of the response
- Effective survey regime (at 1 m intervals), given no migration outside the inner lagoon

Table 2 continues…

[2] SCCAT is the Southern California *Caulerpa* Action Team which is a coordinating and planning body set up to oversee eradication efforts.

Table 2. Sustaining Factors

- Public awareness (2 people)
- They modify their methods as they go along to deal with things they had not considered or to alter their assumptions
- Willing to adapt
- Treatment technique

Table 3. Restraining Factors

Listing of the factors the Scientific Review Panelists considered as restraining or holding back the likelihood of eradication success. Each factor was ranked by the person offering it and presented here with those factors rated as most important appearing nearer the top of the table. This is a catalogue of all the ideas presented for discussion, not a consensus of the Panel. When more than one person made the same comment, (*x* people) signifies the number of people listing the same factor at the same importance level. If two or more scientists made the same comment but rated it at different importance levels, the comment appears more than once in the table. The scientist's words were used here with any facilitator's explanatory notes inside [brackets].

- Lack of basin-wide treatment
- Lack of an established standing (i.e., formal) multi-agency group to deal with the problem
- Lack of ownership by a government agency
- Inadequate incorporation of help from the scientific community
- After initial response, lack of putting (surveillance, containment, eradication) out to competitive bid
- Research (lack of) based on science
- Did not consult with local, national, or international experts (consult early and often)
- Spent time surveying in other areas [rather than developing efforts where invasions were located]
- Potential lack of long-term funding
- There was no connection [of SCATT or contractor] with scientists and researchers
- *Caulerpa* biology [robustness of]
- Jurisdictional problems (e.g., 20 permits needed for Dana Point) and private ownership issues
- Lack of public awareness (with brochures that include maps, more information and different information for different publics)
- Education [lack of]
- Public awareness [lack of]
- Communication to the public [lack of]
- Lack of quarantine of infected areas
- Research [lack of]
- No apparent development of [an] eradication strategy using multiple methods (cost benefit)
- Method of self-evaluation in terms of graphs, summary statements, etc. [lack of]
- Lack of science input
- Need to set specific goals and then evaluate if they are achieved

Table 3 continues…

Table 3. Restraining Factors

- Fragmentation [of the plant] should be absolutely avoided (besides [prohibiting] anchoring no activity for *x* years - make the people participate)
- Legislation (quarantine) [lack of]
- Surveys less frequent but with more divers and in clearer waters [deal with turbidity issues]
- Computer modeling of the situation and the situation if you do not eradicate
- Control / survey (more sites?)
- Insufficient expertise with respect to the science (e.g., statistical design; data collection to analysis; biology)
- Delay in convening a Scientific Review Panel
- Treatment technique is not at the appropriate scale
- Quarantine [lack of]
- Contractor should not be a member of SCCAT ([should be available to] make presentations, answer questions, etc.) otherwise there is a conflict of interest
- Funding [lack of]
- Public attention span [lack of]
- [Lack of] Research and more coordination [needed] on major points for the eradication
- Poor documentation of methods / management
- "Engineering" approach (one-dimensional) [failure to consider the problem as more complex than a tarp and kill process]
- *Caulerpa* [invasiveness and robustness]
- Too many [management] organizations - source of conflicts
- Quantify sampling adequacy and effectiveness for every eradication task - need to know cost and success per unit of effort and dollars
- Lack of bringing aboard hydrodynamic (flow regime dynamics) expertise
- Communication with the scientific community needs improvement
- Consider tarping the whole area instead of surveying each day
- Unpredictable situation
- Have SCCAT member visit the European situation and administrations in the first year
- Survey
- Continued funding
- After initial (summer 2000) response, lack of scientific input at all levels (containment, surveillance, and eradication)
- Publication [is needed] in a peer reviewed [journal of] the history and management [of this case]
- Wider surveillance
- Communication [lack of]
- Built-in conflict / constraint - eradication [versus] science / research
- Advertisements [not at] maximum - to surveillance of the coast
- Habitat (water turbidity)

PROGRAM MODIFICATION RECOMMENDATIONS

The Management Toolbox. The Panelists defined a five component framework, or "toolbox," that provides the context of their recommended program improvements: administration, detection, eradication, prevention, and accelerated learning. From this context, the Panelists made seventeen recommendations that were ranked in importance and presented here with the most important recommendations for program change appearing toward the top of the list.[3]

1. Commission an independent scientific evaluation of the treatment efforts in the two current infestation locations using new, independent field data as well as existing data to evaluate eradication effectiveness and cost versus benefit efficiencies.

2. Develop a protocol for immediately including biological and physical (e.g., hydrodynamic) scientists if a new *Caulerpa* sp. infestation is found (i.e., establish this as part of the surveillance, containment, and eradication efforts) and guarantee access to infestation sites and specimens for legitimate scientific study.

3. Alter the current California legislation to ban the entire genus *Caulerpa* from the state.

4. Increase the use of quarantines (i.e., institute complete area closures to all activities that would disperse *Caulerpa taxifolia* outside each infested area).

5. Increase education efforts that focus on the press, the public, and elected officials as separate audiences. Extend this education to reflect the broader issues of other invasive species and problems.

6. Institute mandatory reporting of *Caulerpa* sp. sightings and mandatory genetic identification of all new infestations.

7. Instigate three types of biological research on *Caulerpa taxifolia*: (1) induction of sexual reproduction; (2) dormancy periods of stolons and rhizoids; and (3) physiological tolerance limits.

[3] Multi-voting was used to determine the group's priorities. In multi-voting, after the recommendations are listed, each member is given several votes (five in our voting) to distribute in whatever way reflects their priorities. This voting simulates the dynamic of a manager's usual problem of allocating limited resources (e.g., money or labor) between competing priorities.

8. Maintain surveillance and rapid response capability (e.g., maintain persistence, the ability to pulse, or increase the response, and the guarantee of sufficient funding). Consider as a standard the institutional capacity to mount new eradication efforts within a month of new infestation discoveries.

9. Establish ongoing detection and survey work outside the current infestation sites.

10. Establish a lead agency with a management charter and supported with a formal, multi-agency implementation committee (i.e., create program focus, authorities, and accountability).

11. For both Huntington Harbour and Agua Hedionda Lagoon consider treating the entire infected area, not just current plant locations.

12. For the purpose of guiding future detection surveys, develop a linked fragment-transport and growth model, calibrated with Agua Hedionda Lagoon data, to predict dispersal and growth.

13. Develop a spatially discrete population model from time-series eradication data (to inform detection strategies, risk prediction, design of search efforts, eradication success assessments, and judgments about the needed spatial extent of treatments).

14. Begin the acquisition (or assimilation of existing) temperature and other physical environmental data and the comparison of these to an evaluation of temperature and physiological tolerances of southern California *Caulerpa taxifolia* populations (i.e., perform a risk assessment of vector hazards and potential invasive ranges).

15. Instigate a rigorous scientific review of protocols for surveillance, containment, and eradication and a rigorous, quantitative reporting of how protocols were carried out.

16. Commission a technical, scientific report of various eradication methods for *Caulerpa taxifolia* and, secondarily, for other top invasive marine algae.

17. Publish, in an international, peer-reviewed journal, a case history of the California infestations and resultant detection, eradication, prevention, and institutional response efforts.

CLOSING EXERCISE - RECONSIDERATION OF THE MANAGEMENT HISTORY ASSESSMENT

At the end of the day, the Panelists decided to repeat the opening exercise having gone through their deliberations and discussions. This time, on a scale of 0 to 10, the Panelists re-considered their opinions about the likely success of current eradication efforts (Figure 2). The result was no substantive change in the distribution of the scientists' opinions.

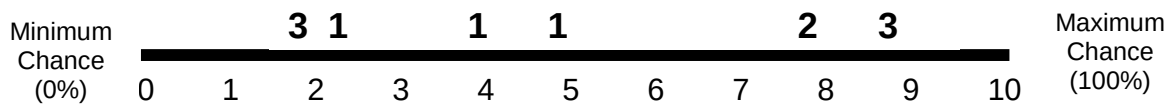

Figure 2. The Scientific Review Panelists' re-considered opinions about the likelihood of current *Caulerpa taxifolia* eradication efforts in California totally eradicating a new, similar infestation. The number of scientists is denoted by the numbers above the line, using a 0-10 scale (appearing below the line).

EVALUATION OF THE SCIENTIFIC REVIEW PANEL PROCESS

The scientists participating in this review were asked to reflect on their experience on the Panel and offer evaluation comments for improving the process. The next Scientific Review would be improved if:

> There are one or more site visits; the same Panel members participate (to provide knowledge growth and institutional memory); there is a technical conference before convening the Scientific Review Panel; the background information packet and contractor report are distributed well before the Panel meeting; the contractor is, once again, available to meet with the Panel; there is use of a facilitator; there is a designated note taker to help with the meeting record; the expectations of Scientific Panel are more clearly spelled out ahead of time; a longer meeting is scheduled; there is travel cost assistance for those without budgets to support this kind of technical assistance; and there is a mix of in-person and electronic meetings with in-person meetings, perhaps twice a year.

EVALUATION OF THE MEETING

The scientists participating in this meeting were asked and provided the following ideas for improving management of their next meeting:

> Continue to mix different activities to change meeting interactions; use a facilitator; create an environment more conducive to interpersonal interactions and communication between the Panel, contractor, and local experts; and, once again, have a well organized agenda for the Scientific Review Panel meeting.

SUPPLEMENTAL COMMENTS

Panelists were invited to provide supplemental comments in writing after the February 2 Scientific Review Panel meeting. Two scientists did so (Appendices 2 and 3). These, in general terms, stressed three broad topics. First were issues surrounding the eradication efforts, including: concerns about the absence of scientific review and input in the eradication effort up to the February meeting; the positive value of the Panel's interaction with the contractor; concern that several key outcomes from this session relevant to the performance assessment had not been considered; a recommendation to increase the rigor of the eradication and assessment methods; and identification of some program management shortcomings. These considerations were felt to be "…eye-opening and … intrinsic to our review process and the results from these findings lead to a series of scientific recommendations…" but were not otherwise captured in the meeting record (Appendix 2).

Second was improving the organization of the Scientific Review Panelists' assessments presented in Tables 2 and 3. The sustaining and restraining factors fall into logical management categories and doing so would have provided a better framework for managers to use in designing changes to the eradication effort. Such revisions to these tables are provided in Appendix 2.

And third was a positive assessment that the information provided indicates a probable eradication potential for the California effort (Appendix 3).

APPENDIX 1

AGENDA

Caulerpa taxifolia Scientific Review Panel
February 2, 2002
San Diego, California, U.S.A.

A. Introductions.

B. Meeting purpose.

C. Question and answer session with local experts.

D. Exercise: management history assessment.

E. Exercise: sustaining and restraining factors.

F. Program modification recommendations.

G. Evaluation of the Scientific Review Panel process.

H. Evaluation of the meeting.

- -

On February 3 there was a site visit to Agua Hedionda Lagoon for available Scientific review Panel members. This was an unscheduled but valuable addition to the activities of the Scientific Review Panel.

APPENDIX 2

SUPPLEMENTAL COMMENTS TO THE *Caulerpa taxifolia* SCIENTIFIC REVIEW PANEL PROCEEDINGS

By: Dr. Chad Hewitt
Invasion Biologist
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The Scientific Review Panel's report would have benefited by including results from the discussion and question/answer period we had with the contractor. I felt this conversation was extremely useful and provided a good "discovery" period where we began to understand some of the motivating points behind the current eradication activities. Clearly, the quality assurance and quality control role that the Scientific Review Panel is supposed to play has been compromised by the long delay (18 months) between incursion response and the panel review. Consequently, the session with the contractor provided useful information relevant to the record of the meeting.

Because that part of the meeting was not recorded and because the items we uncovered were important I would like to provide my observations of the key outcomes from this session. These discoveries included the disparity between size of ' debris field' and treatment method; the lack of a spatial analysis to determine if eradication efforts were enhancing recruitment; growth rates of individual rhizomes and patches; an unclear decision making process to determine when (and under what circumstances) research should be conducted along side the eradication efforts; an unclear decision making process to determine when quarantine should or should not be used; and a lack of clear and concise records of changes in eradication protocols.

These items were eye-opening and I thought intrinsic to our review process and the results from these findings lead to a series of scientific recommendations for: 1) evaluating existing data from the eradication effort; 2) future research that needs to occur in the two incursions; and 3) immediate recommendations for changes to the existing activities including protocol development.

The findings presented in Tables 2 and 3 of the Proceedings would be more useful if they had been further organized by the Panel. In these tables I can see logical program management categories under which the Panel's evaluations of supporting (sustaining) or hindering (restraining) factors can more clearly reveal opportunities to improve the eradication program. I have made these judgments from the Panelists' remarks and present them here as reorganized tables.

I' ve reorganised the tables to try and place like comments together under broad categories that were discussed since many of the comments are related and/or redundant. For example, the ' Rapid Response' option had four very similar comments: Rapid Response (3 people); Rapidity of Response; Rapid response (survey and eradication of the two infested areas); and Good initial response (quick and decisive). Where I authored a new heading for set of statements made by participants I have placed these in italics. I realise this changes the statement in the table title that the highest ranked statements are nearer the top of the list.

Appendix 2, Table 2. Sustaining Factors.

Dr. Chad Hewitt's notes are inside {braces and *italicized*}.

Listing of the factors the Scientific Review Panelists considered as sustaining or supporting the likelihood of eradication success. ***{ SEE PARAGRAPH, ABOVE*** } ~~Each factor was ranked by the person offering it and presented here with those factors rated as most important appearing nearer the top of the table. This is a catalogue of all the ideas presented for discussion, not a consensus of the Panel. When more than one person made the same comment, (*x* people) signifies the number of people listing the same factor at the same importance level. If two or more scientists made the same comment but rated it at different importance levels, the comment appears more than once in the table.~~ The scientist's words were used here with any facilitator's explanatory notes inside [brackets].

1) Development of Initial action plans

2) Early Agreement on outcome/goal (eradication)

3) *{ Team building }*

a) Team building

b) Formation of SCCAT[4]

c) Organized into mission-oriented team

d) American psyche ["Can-Do" attitude]

e) Dedicated effort (not just a contract)

f) Energetic, dedicated concern - they are passionate about eradication

g) Willing to adapt

h) They modify their methods as they go along to deal with things they had not considered or to alter their assumptions

Table 2 continues…

[4] SCCAT is the Southern California *Caulerpa* Action Team which is a coordinating and planning body set up to oversee eradication efforts.

Appendix 2, Table 2. Sustaining Factors.

i) Asked for help from foreign scientists
j) Experience from the Mediterranean Sea (in Croatia) indicates California eradication is possible

4) Persistence of effort

5) *{ Funding }*

a) Level of funding dedicated to the problem
b) Effective funding procurement

6) *{ Rapid response }*

a) Rapid response (3 people)
b) Rapid response
c) Rapidity of the response
d) Rapid Response
e) Rapid response (survey and eradication of the two infested areas)
f) Good initial response (quick and decisive)

7) Treatment technique

a) Tarp and chlorine - effective eradication method - no regrowth
b) Technique of eradication with no remnant toxics

8) *{ Success }*

a) Managed to eradicate a large portion of the population within one year
b) Eradication is going well
c) Situation is under control

9) *{ Surveillance }*

a) High frequency of surveys
b) Continuous surveillance
c) Effective survey regime (at 1 m intervals), given no migration outside the inner lagoon

10) Public awareness (2 people)

Appendix 2, Table 3. Restraining Factors.

Dr. Chad Hewitt's notes inside {braces and *italicized*}.

Listing of the factors the Scientific Review Panelists considered as restraining or holding back the likelihood of eradication success. ***{ SEE PARAGRAPH, ABOVE }*** ~~Each factor was ranked by the person offering it and presented here with those factors rated as most important appearing nearer the top of the table. This is a catalogue of all the ideas presented for discussion, not a consensus of the Panel. When more than one person made the same comment, (*x* people) signifies the number of people listing the same factor at the same importance level. If two or more scientists made the same comment but rated it at different importance levels, the comment appears more than once in the table.~~ The scientist's words were used here with any facilitator's explanatory notes inside [brackets].

1) Legislation (quarantine) [lack of]

2) *{ Jurisdiction }*

a) Lack of ownership by a government agency
b) Lack of an established standing (i.e., formal) multi-agency group to deal with the problem
c) Jurisdictional problems (e.g., 20 permits needed for Dana Point) and private ownership issues
d) Too many [management] organizations - source of conflicts

3) Need to set specific goals and then evaluate if they are achieved

4) No apparent development of [an] eradication strategy using multiple methods (cost benefit)

5) *{ Research/Science }*

a) Inadequate incorporation of help from the scientific community
b) Did not consult with local, national, or international experts (consult early and often)
c) Research (lack of) based on science
d) Did not consult invasion biologists or statisticians to calculate dispersal, clonal growth, etc. (consult early and often)
e) There was no connection with scientists and researchers
f) Research [lack of]
g) Lack of science input
h) After initial (summer 2000) response lack of scientific input at all levels (containment, surveillance, and eradication)
i) Publication in a peer reviewed [journal] the history and management [of this case]
j) [Lack of] Research and more coordination [needed] on major points for the eradication
k) Insufficient expertise with respect to the science (e.g., statistical design; data collection to analysis; biology)
l) Delay in convening a Scientific Review Panel
m) Communication [lack of]
n) Communication with the scientific community needs improvement
o) Lack of bringing aboard hydrodynamic (flow regime dynamics) expertise
p) Built-in conflict / constraint - eradication [versus] science / research

6) *{ Caulerpa biology }*

a) *Caulerpa* biology [robustness of]
b) *Caulerpa* [invasiveness and robustness]

Table 3 continues…

7) *{ Public awareness }*

a) Lack of public awareness (with brochures that include maps, more information and different information for different publics)
b) Education [lack of]
c) Public awareness [lack of]
d) Communication to the public [lack of]
e) Public attention span [lack of]
f) Advertisements [not at] maximum - to surveillance of the coast

8) *{ Methodology }*

a) After initial response, lack of putting (surveillance, containment, eradication) out to competitive bid
b) Spent time surveying in other areas rather than developing efforts where invasions were located
c) Fragmentation [of the plant] should be absolutely avoided (besides anchoring [prohibition] no activity for *x* years - make the people participate)
d) "Engineering" approach (one-dimensional)
e) Poor documentation of methods / management
f) Computer modeling of the situation and the situation if you do not eradicate
g) Quantify sampling adequacy and effectiveness for every eradication task - need to know cost and success per unit of effort and dollars
h) Method of self-evaluation in terms of graphs, summary statements, etc. [lack of]
i) Treatment technique is not at the appropriate scale
j) Quarantine [lack of]
k) Lack of quarantine of infected areas
l) Lack of basin-wide treatment
m) Consider tarping the whole area instead of surveying each day
n) Contractor should not be a member of SCCAT ([should be available to] make presentations, answer questions, etc.) otherwise there is a conflict of interest
o) Surveys less frequent but with more divers and in clearer waters [deal with turbidity issues]

9) Have SCCAT member visit the European situation and administrations in the first year

10) Survey

a) Control / survey (more sites?)
b) Wider surveillance

11) Funding

a) Continued funding
b) Potential lack of long-term funding

12) Habitat (water turbidity)

13) Unpredictable situation

APPENDIX 3

SUPPLEMENTAL COMMENTS TO THE *Caulerpa taxifolia* SCIENTIFIC REVIEW PANEL PROCEEDINGS

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On the basis of:

- The presentation by SCCAT members on the eradication program;
- personal communication with SCCAT members;
- the document: 'In progress review: Ancillary data and observation from *Caulerpa taxifolia* eradication efforts at Agua Hedionda and Huntington Harbour of the SCCAT. January 2002, Merkel & Associates, Inc. San Diego; and
- personal experience with *Caulerpa taxifolia* eradication in the Adriatic Sea

I would like to provide the following observations on the eradication effort in California.

The results of current *Caulerpa taxifolia* eradication progress in Agua Hedionda Lagoon and Huntington Harbour indicates that a complete eradication of the invasive species will be achieved. This seems possible because, first, there are significant reductions in the extent of the algae's coverage since the beginning of the eradication program and, second, due to the high intensity of the surveillance effort (one meter transect spacing), it seems probable that all plants (but not all fragments) have been found and treated. While the latest plant discoveries were during Fall 2001, most probably numerous algae fragments, most likely pieces of fronds, remain in the buffer area. These fragments are probably covered by mud and are difficult to find, even with the one-meter transect spacing in the surveillance effort.

Undetected fragments will remain dormant during the winter and start to regenerate when seawater temperatures reach approximately 18^{o}C.

As new plants grow from the fragments the algae will become easier to detect. It is expected that during the next spring/summer period, numerous small algae plants will appear inside the buffer fields due to regeneration of over-wintered fragments. New plants have to be eradicated when they are beginning to regenerate, before they become a source of new fragments. Because of this it is important to intensify the surveillance to the maximum level when increasing seawater temperatures induce a regeneration processes.

Eradication methods should be chosen separately for the each plant/fragment that is found. Covering plants with a tarp and using the chlorine treatment ensures a maximum chance for eradicating discovered plants. Because of the siphon structure of *Caulerpa taxifolia*, it is more likely that chlorine has a lethal effect on the sub-surface stolons and rhizoids. Even if they survive chlorine treatment, it is highly possible that they cannot survive the anoxic conditions under a tarp.

Based on the eradication progress reported in California and our experience eradicating *Caulerpa taxifolia* on the similar habitat in Croatia, it is expected that the last appearance of *Caulerpa taxifolia* in Agua Hedionda Lagoon and Huntington Harbour will be during growing seasons of 2003 - 2004.